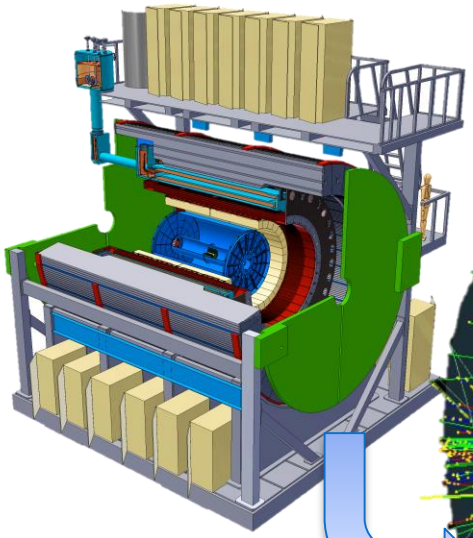
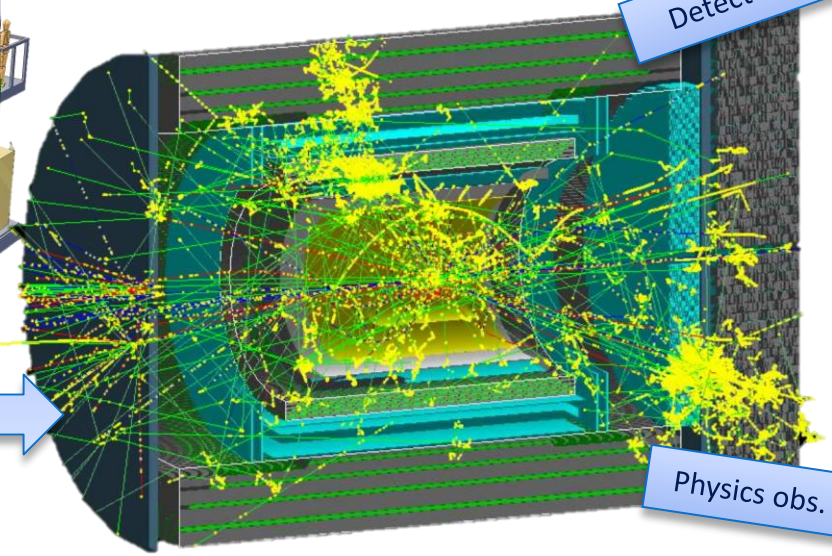
Introduction to sPHENIX tracking software

Anthony Frawley (Florida State University)
Jin Huang (Brookhaven National Lab)
Michael McCumber (Los Alamos National Laboratory)
Chris Pinkenburg (Brookhaven National Lab)

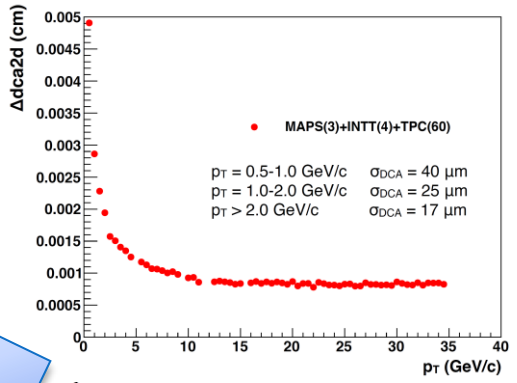
sPHENIX tracking software

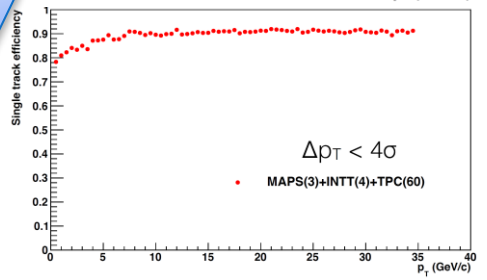
https://github.com/sPHENIX-Collaboration/coresoftware



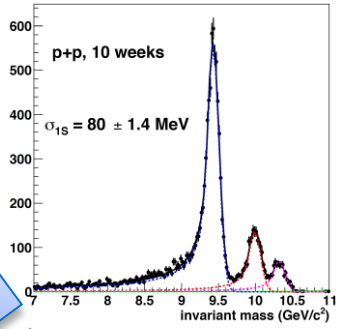


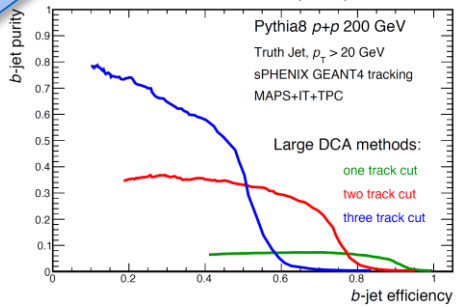
Detector performance





Physics obs. Projection





Ref. Design

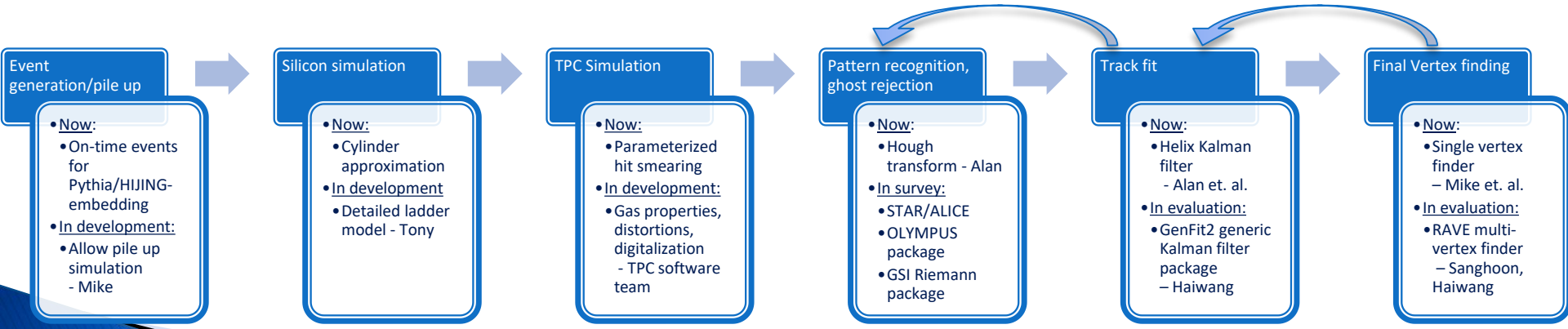
- 3-layer MAPS
- 4-layers Silicon strip
- TPC (30-78 cm active)

→ G4 Simulation
→ Digitization
→ Reconstruction →

sPHENIX sim and analysis framework (Fun4All)

sPHENIX tracking simulation and reconstruction chain

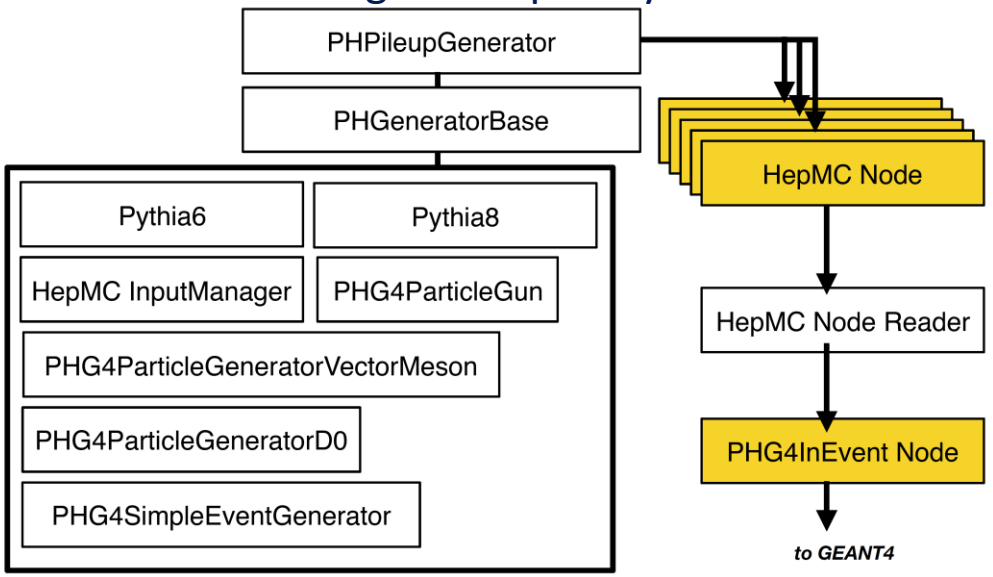
- A chain of full detector Geant4 simulation and reconstruction software developed for sPHENIX, used in current detector and physics performance projection
- Limitations in current software that need to be evolved for the next stage
- Many new developments hold back before the Sept-tracking review. Now to be coordinated to be made default.



Event generation with pile up support

- Pile up in event generation required for integrated detector simulation (TPC, MAPS)
- [In-development]
  Mike reworked on the event generator framework and digitization with timing dependence
- Talk by Mike today

New event generator framework as being developed by Mike McCumber



Event generation/pile up
- Now:
  - On-time events for Pythia/HIJING-embedding
- In development:
  - Allow pile up simulation - Mike

Silicon simulation
- Now:
  - Cylinder approximation
- In development
  - Detailed ladder model - Tony

TPC Simulation
- Now:
  - Parameterized hit smearing
- In development:
  - Gas properties, distortions, digitalization - TPC software team

Pattern recognition, ghost rejection
- Now:
  - Hough transform - Alan
- In survey:
  - STAR/ALICE
  - OLYMPUS package
  - GSI Riemann package

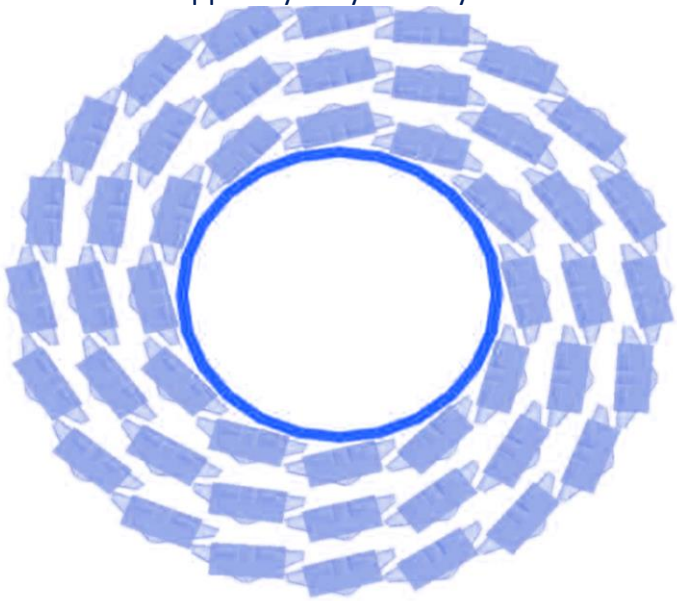
Track fit
- Now:
  - Helix Kalman filter - Alan et. al.
- In evaluation:
  - GenFit2 generic Kalman filter package – Haiwang

Final Vertex finding
- Now:
  - Single vertex finder – Mike et. al.
- In evaluation:
  - RAVE multi-vertex finder – Sanghoon, Haiwang

Silicon tracker simulation

- Geometry in simulation
  - [Default] Current silicon detector was simulated with cylindrical geometry (homogeneously distribute material in phi, one hit per layer). Dead-map simulation support
  - [Ready to merge] Tony et al. imported ALICE ITS model in sPHENIX framework, close to completion.
  - [Idea] Ladder modeling needed for INTT too
  - Require patter recognition / fitting to match too (later slides)
- Digitization of silicon hit
  - [In development] Translation of geometry to reconstruction
  - [Idea] Charge diffusion and sharing
- Talk by Tony today

ITS ladder imported to sPHENIX sim
Developped by Tony Frawley



Event generation/pile up
- Now:
  - On-time events for Pythia/HIJING-embedding
- In development:
  - Allow pile up simulation - Mike

Silicon simulation
- Now:
  - Cylinder approximation
- In development
  - Detailed ladder model - Tony

TPC Simulation
- Now:
  - Parameterized hit smearing
- In development:
  - Gas properties, distortions, digitalization - TPC software team

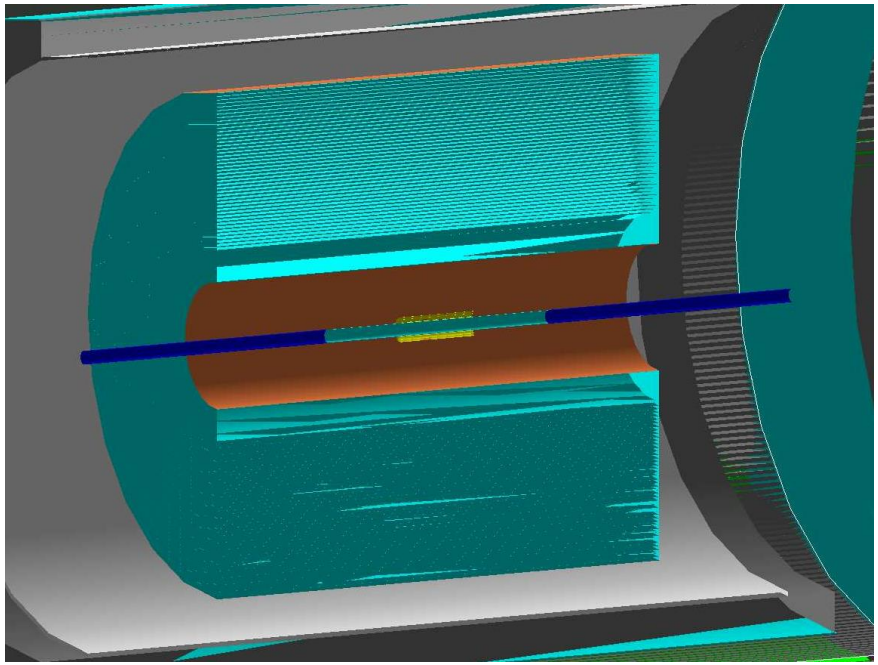
Pattern recognition, ghost rejection
- Now:
  - Hough transform - Alan
- In survey:
  - STAR/ALICE
  - OLYMPUS package
  - GSI Riemann package

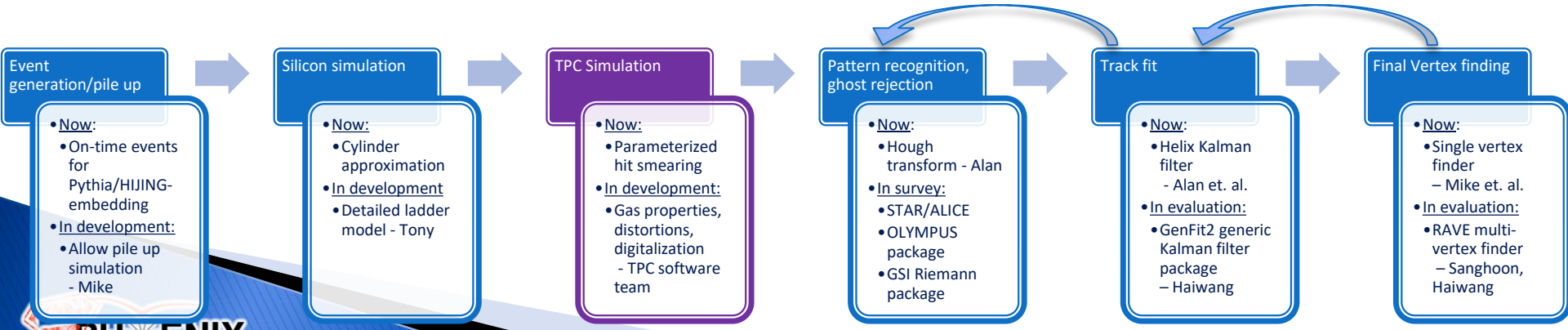
Track fit
- Now:
  - Helix Kalman filter - Alan et. al.
- In evaluation:
  - GenFit2 generic Kalman filter package – Haiwang

Final Vertex finding
- Now:
  - Single vertex finder – Mike et. al.
- In evaluation:
  - RAVE multi-vertex finder – Sanghoon, Haiwang

TPC simulation

- Now:
  - Parameterized hit smearing
  - Apply residual distortion
- In development:
  - Many work on going by TPC software team
  - Geometry dimensions
  - Gas properties
  - Distortions from space charge and electric field
  - Signal digitalization.
- See Sourav's talk today

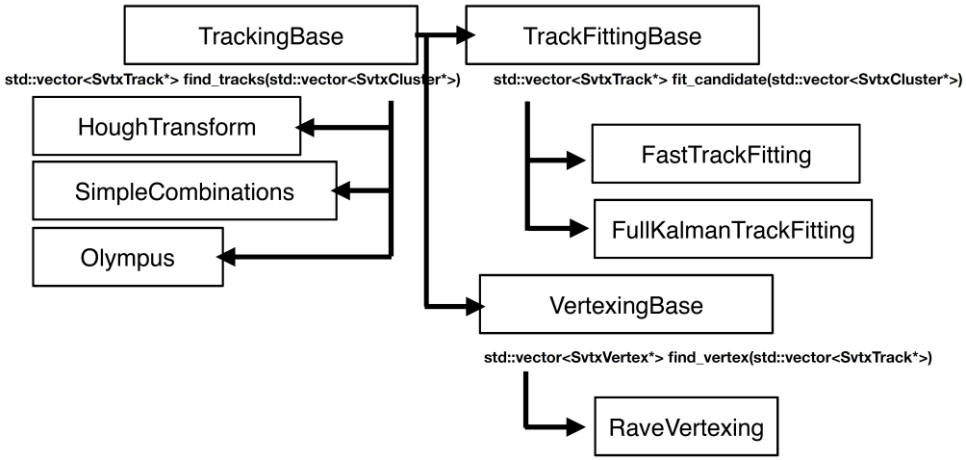


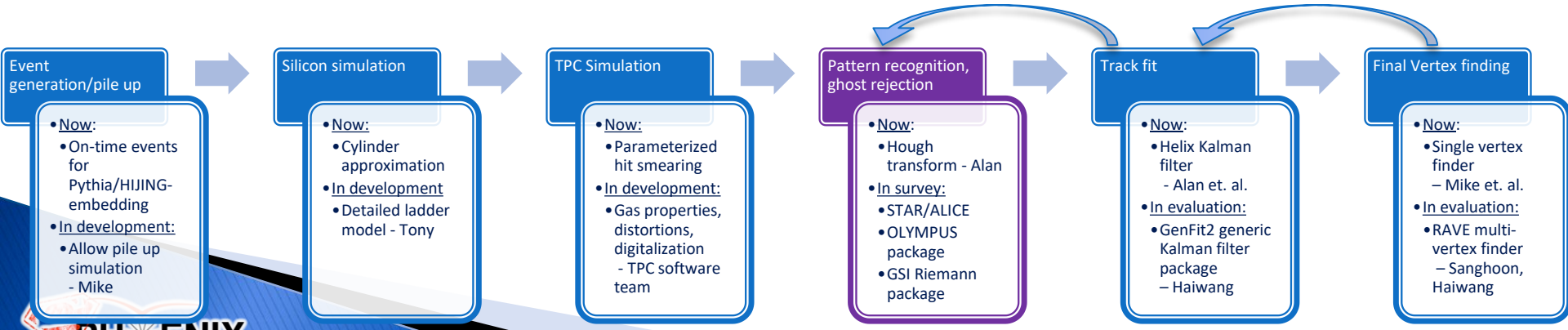


Pattern recognition and ghost rej.

- Default:
  - Helix hough transform on cylindrical geometry-based detector, as part of **PHG4HoughTransformTPC**, by Alan Dion et. al.
- In survey:
  - STAR/ALICE
  - OLYMPUS package
  - GSI Riemann package
- Proposal to modularize patter recognition framework
- Need manpower

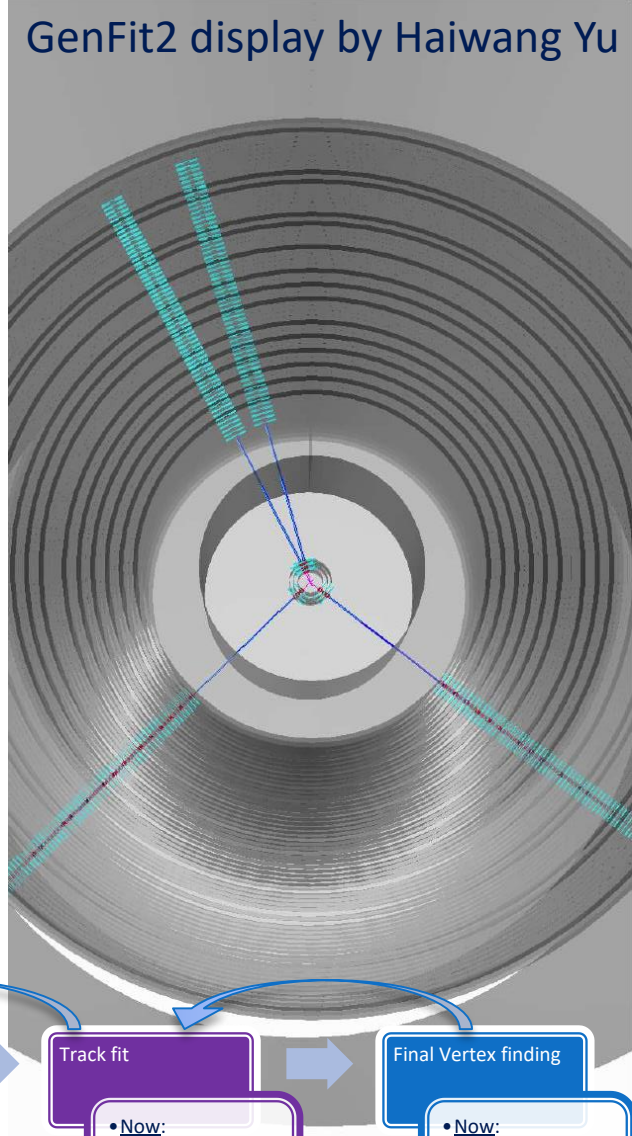
Proposal of modularized patter recognition framework by Mike McCumber





Track Fit

- Default:
  - Helix Kalman filter on cylindrical geometry, as part of **PHG4HoughTransformTPC**, by Alan Dion et. al.
- Merged, not used by default : GenFit2
  - A generic Kalman filter package developed at GSI, imported to sPHENIX by Haiwang Yu et. al.
  - Reproduce Helix Kalman filter results
  - Support G4 geometry import, therefore works for silicon ladders
  - Already use in b-jet tagging with 3D-DCA
  - Possibility to enable fake hit rejection for TPC
  - Talk by Haiwang today



Event generation/pile up
- Now:
  - On-time events for Pythia/HIJING-embedding
- In development:
  - Allow pile up simulation - Mike

Silicon simulation
- Now:
  - Cylinder approximation
- In development
  - Detailed ladder model - Tony

TPC Simulation
- Now:
  - Parameterized hit smearing
- In development:
  - Gas properties, distortions, digitalization - TPC software team

Pattern recognition, ghost rejection
- Now:
  - Hough transform - Alan
- In survey:
  - STAR/ALICE
  - OLYMPUS package
  - GSI Riemann package

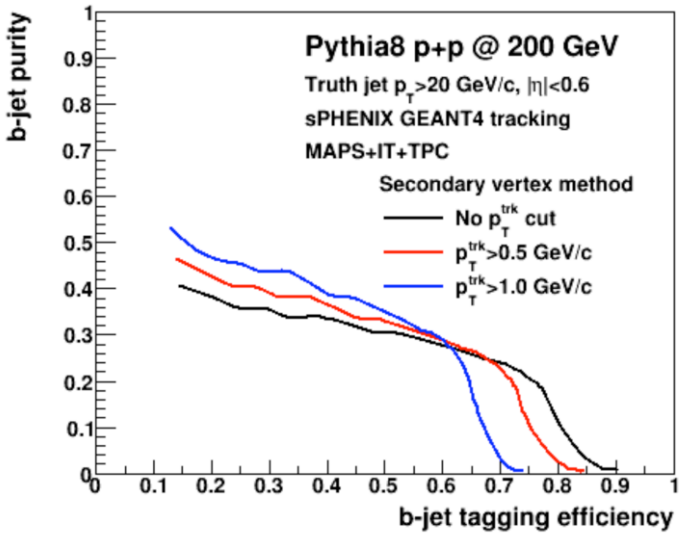
Track fit
- Now:
  - Helix Kalman filter - Alan et. al.
- In evaluation:
  - GenFit2 generic Kalman filter package – Haiwang

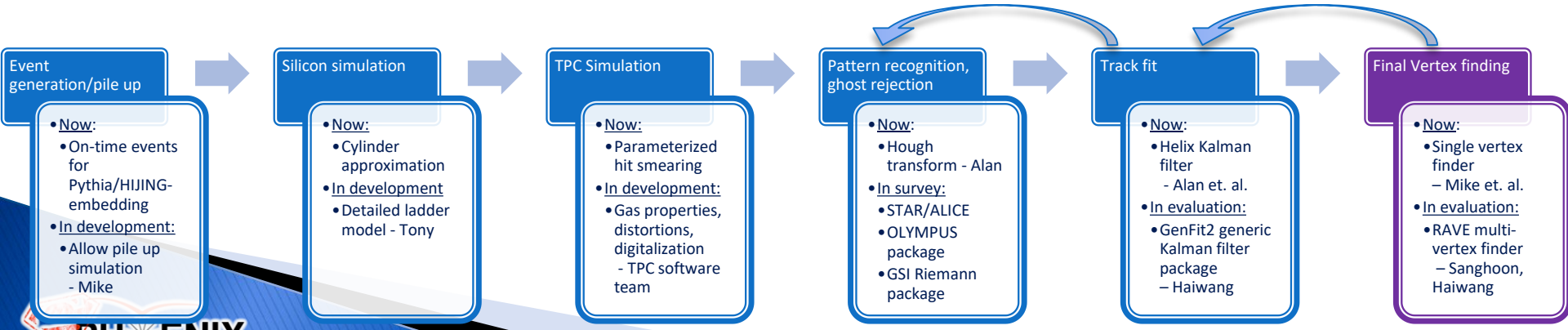
Final Vertex finding
- Now:
  - Single vertex finder – Mike et. al.
- In evaluation:
  - RAVE multi-vertex finder – Sanghoon, Haiwang

Final vertex finding

- Default:
  - Single vertex finder and fitter as part of **PHG4HoughTransformTPC** by Mike et. al.
- Merged, not used by default : RAVE
  - A multi-vertex finder and fitter developed by CMS, imported by Sanghoon Lim and Haiwang Yu
  - Reasonably multi-vertex separation and fitting quality from initial test
  - Also adapted for analyzing secondary vertex in b-jets
  - Talk by Sanghoon today

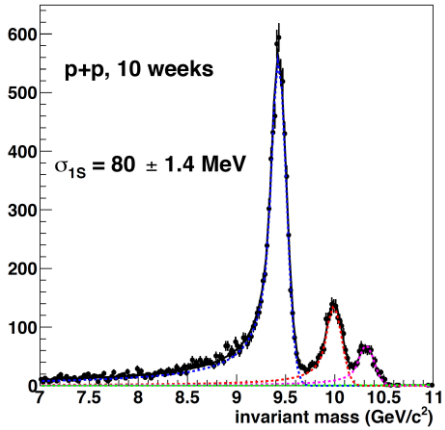
B-jet tagging performance via secondary vertex finder by Sanghoon Lim

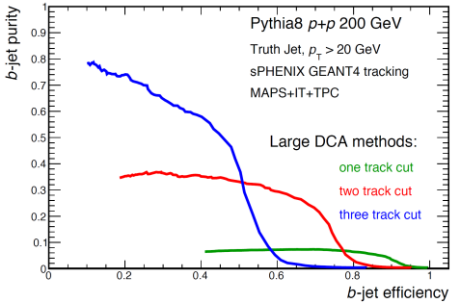




Interfaces to analyzers

- Available
  - Generalized track object
  - Evaluation tools for deep truth tracing
  - Standardized tracking QA tools
- In develop
  - [Merged, not used by default] Primary track fits by Haiwang Yu
  - [Pull request]: Reconstruction event display by Sook Hyun Lim
  - [Test code] DCA-3D fit by Haiwang Yu
  - [Idea] Toolkit to refit track DCA with user selected vertex using GenFit
  - [Idea] Toolkit for calorimeter projections using GenFit





Event generation/pile up
- Now:
  - On-time events for Pythia/HIJING-embedding
- In development:
  - Allow pile up simulation - Mike

Silicon simulation
- Now:
  - Cylinder approximation
- In development
  - Detailed ladder model - Tony

TPC Simulation
- Now:
  - Parameterized hit smearing
- In development:
  - Gas properties, distortions, digitalization - TPC software team

Pattern recognition, ghost rejection
- Now:
  - Hough transform - Alan
- In survey:
  - STAR/ALICE
  - OLYMPUS package
  - GSI Riemann package

Track fit
- Now:
  - Helix Kalman filter - Alan et. al.
- In evaluation:
  - GenFit2 generic Kalman filter package – Haiwang

Final Vertex finding
- Now:
  - Single vertex finder – Mike et. al.
- In evaluation:
  - RAVE multi-vertex finder – Sanghoon, Haiwang

This meeting

- Goal: coordinate development tracking software chain after the encouraging tracking detector review.
- Survey: STAR, ALICE and Olympus tracking software
- Status and plan for the components of our tracking software. Many new developments hold back before review. Now to be coordinated to be made default.
- Forums of detailed discussion and updates:
  - Tracking meeting, Fri 9AM
  - sPHENIX simulation/software meeting: Tue 1-2 PM
  - TPC software meeting, Thu afternoon